Cross-Comparison of Aura MLS and Aqua AIRS Cloud Measurements

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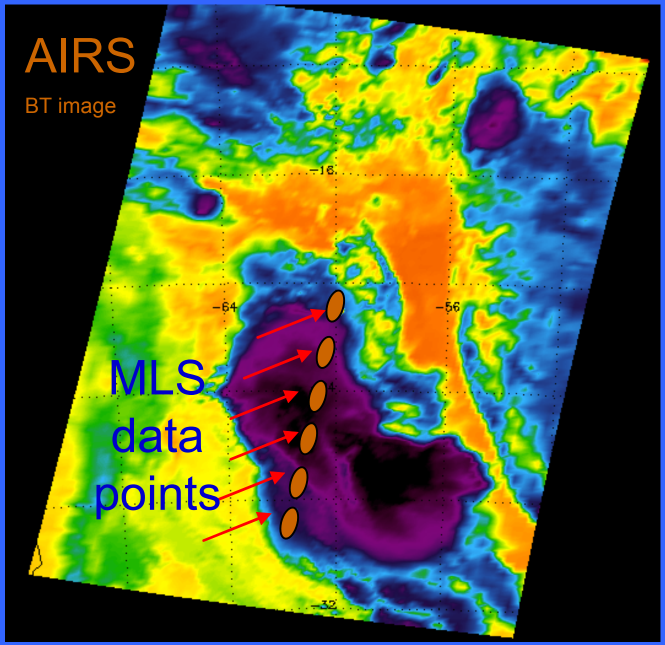
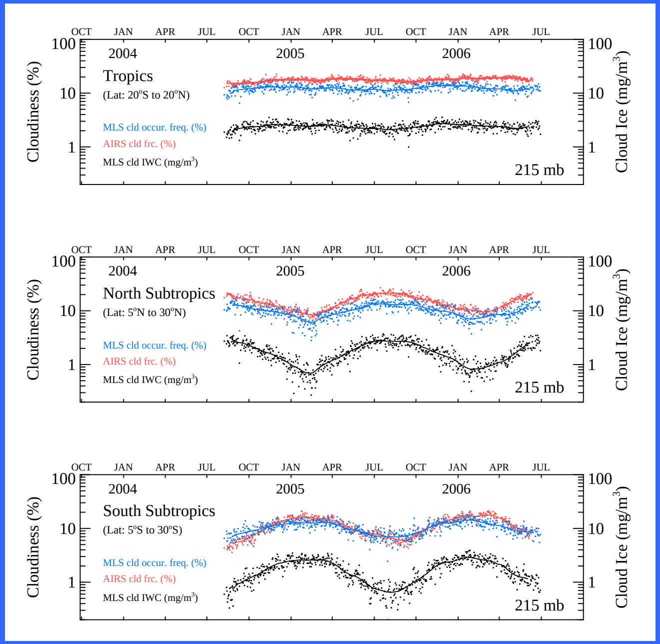
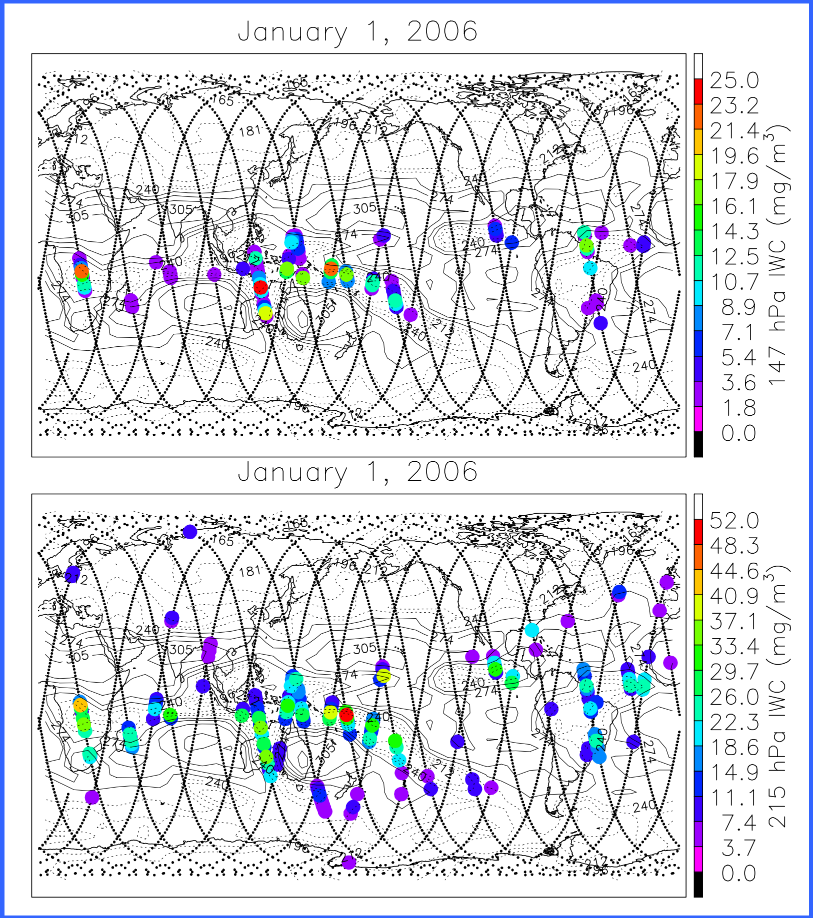




Description Aura MLS Cloud IWC Data

Aura MLS Version 1.5 [*Livesey et al*. 2005] Lever 2 ice water content (IWC) product is used in this study. The useful vertical range for IWC is pressures ≤ 215 hPa. The IWC single measurement precision ranges from 0.4 mg/m^3 at 100 hPa to 4 mg/m^3 at 215 hPa. The IWC retrievals greater than ~50mg/m^3 are subject to larger error due to radiance saturation.

Caution: when using the V1.5 IWC data downloaded from the DAAC, one must use a data screen procedure, as well as a set of data correction factors described in Livesey et al, [2005]. Alternatively, data users can use an off-line reprocessed data set, downloadable at
ftp://mls.jpl.nasa.gov/pub/outgoing/jonathan/mls_cld/

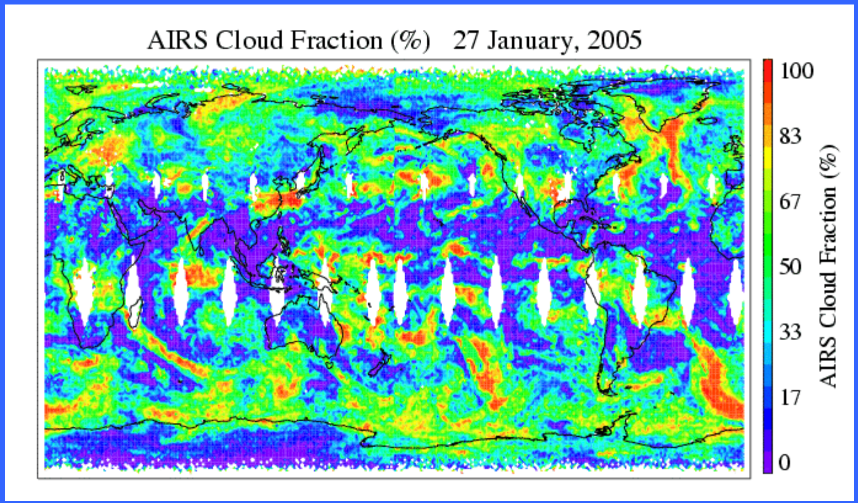


An example of Aura MLS daily cloud IWC measurements at 147 hPa (top panel) and 215 hPa (lower panel).

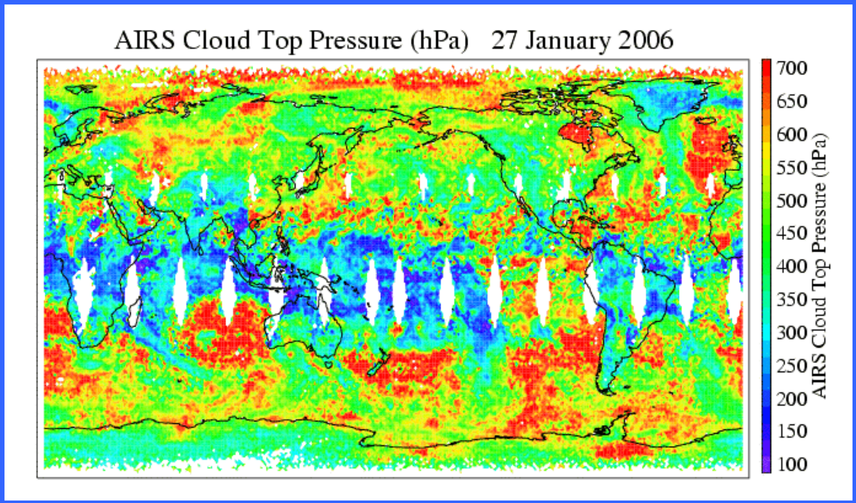
Description Aqua AIRS Cloud CFR and CTP data

Aqua AIRS Version 4.0 [*Olsen et al*. 2005]] Level 3 Cloud Fraction (CFR) and Cloud Top Pressure (CTP) data are used for this study. These products are assembled from the AIRS Level 2 products that have been filtered using their respective quality flags. Quality controls are applied to each data point both for different parameters and at different levels in the atmosphere for a profile.

Caveats: AIRS CTP data are recommended for pressure ≥150 hPa. AIRS cloud retrieval at higher altitude are relatively poorer due to weaker signal in AIRS radiances relative to noise; Also, during the AIRS retrieval when a cloud is sensed above the tropopause, the cloud is put back in where the tropopause exists. Therefore, the retrieved AIRS CTP is often biased high (i.e. cloud top height is often biased low).



An example of
AIRS daily CFR measurements



An example of
AIRS daily CTP measurements

Differences between the two instruments

- MLS senses through clouds horizontally, AIRS observes radiance from a vertical or-near-vertical atmospheric column.

- MLS views in the forward along-track direction, with the tangent altitude trailing the AIRS nadir observations by only ~ 8 minutes. Although the viewing geometry-related differences likely dominate over those due to the cloud evolution, fast evolving clouds can not be dismissed in convection, e.g. a typical vertical velocity ~10 m/s in deep convection translates ~ 4km in 8 min.

- MLS FOV is about 165 km x 7 km (along-track x cross-track), AIRS FOV is ~ 45 km circular.

- MLS is sensitive in detecting ice particles from a few tens to a few hundreds of microns in diameter in relatively dense clouds (e.g. cumulonimbus clouds such those associated with deep-convection and its anvil outflow). AIRS is sensitive to relative tenuous clouds but saturates around an IR optical depth above 5.

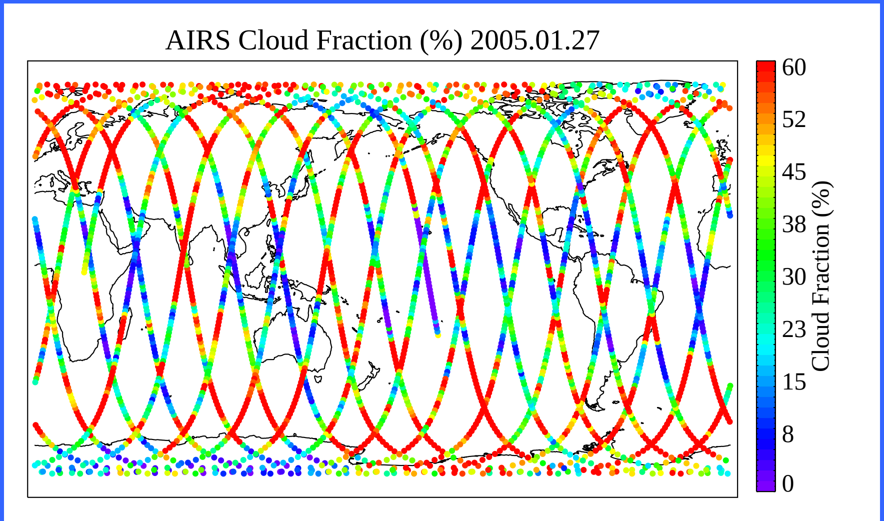
Comparison between MLS with AIRS Observations

First step:

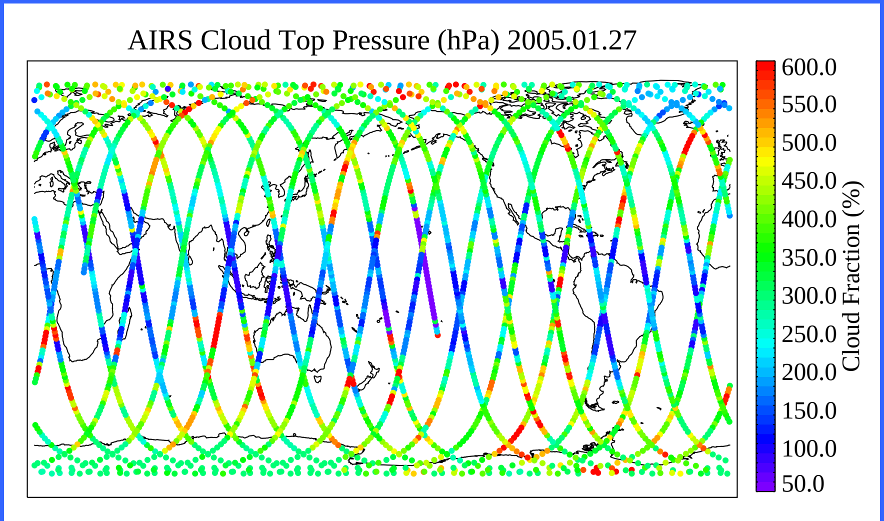
To find collocated and coincident cloud observations between MLS and AIRS, the first step is to interpolate the AIRS data onto MLS track. That is, on each MLS measurement point,

(1) the sampled AIRS CFR, ⟨**CFR**⟩, is the average of AIRS CRF in a box of ±2° along track and ±1° cross track, centered on the MLS data point.

(2) the sampled AIRS CTP, ⟨**CFR**⟩, is the smallest AIRS CTP (i.e. highest cloud top height) in the same 2° by 1° box.



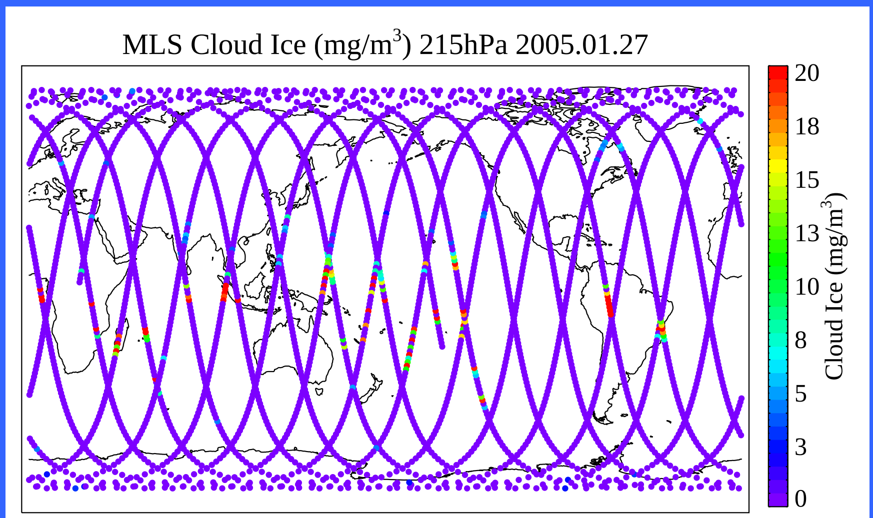
AIRS daily ⟨CFR⟩ sampled on MLS track

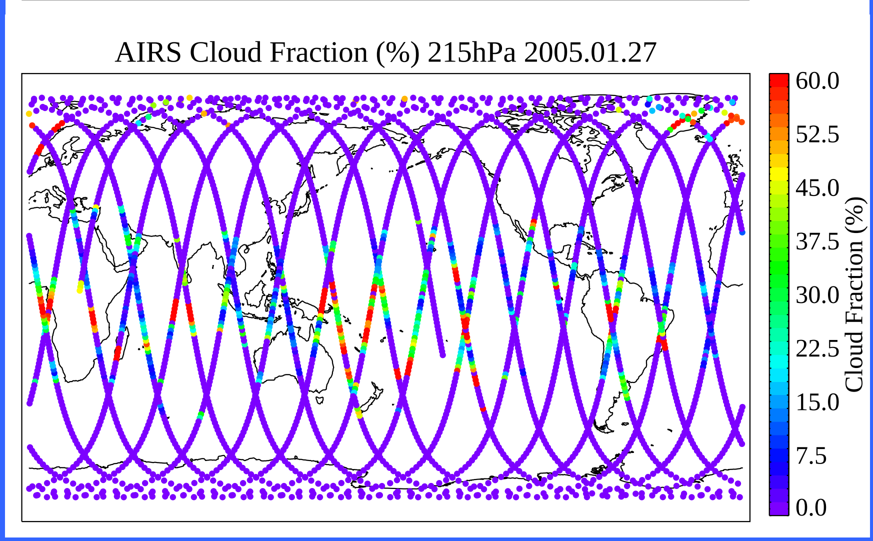


AIRS daily ⟨CTP⟩ sampled on MLS track

Second step:

In order to do comparison for each MLS pressure levels, we bin the AIRS ⟨**CFR**⟩ according to AIRS ⟨**CTP**⟩ at ≤ 215hPa, 147 hPa etc.



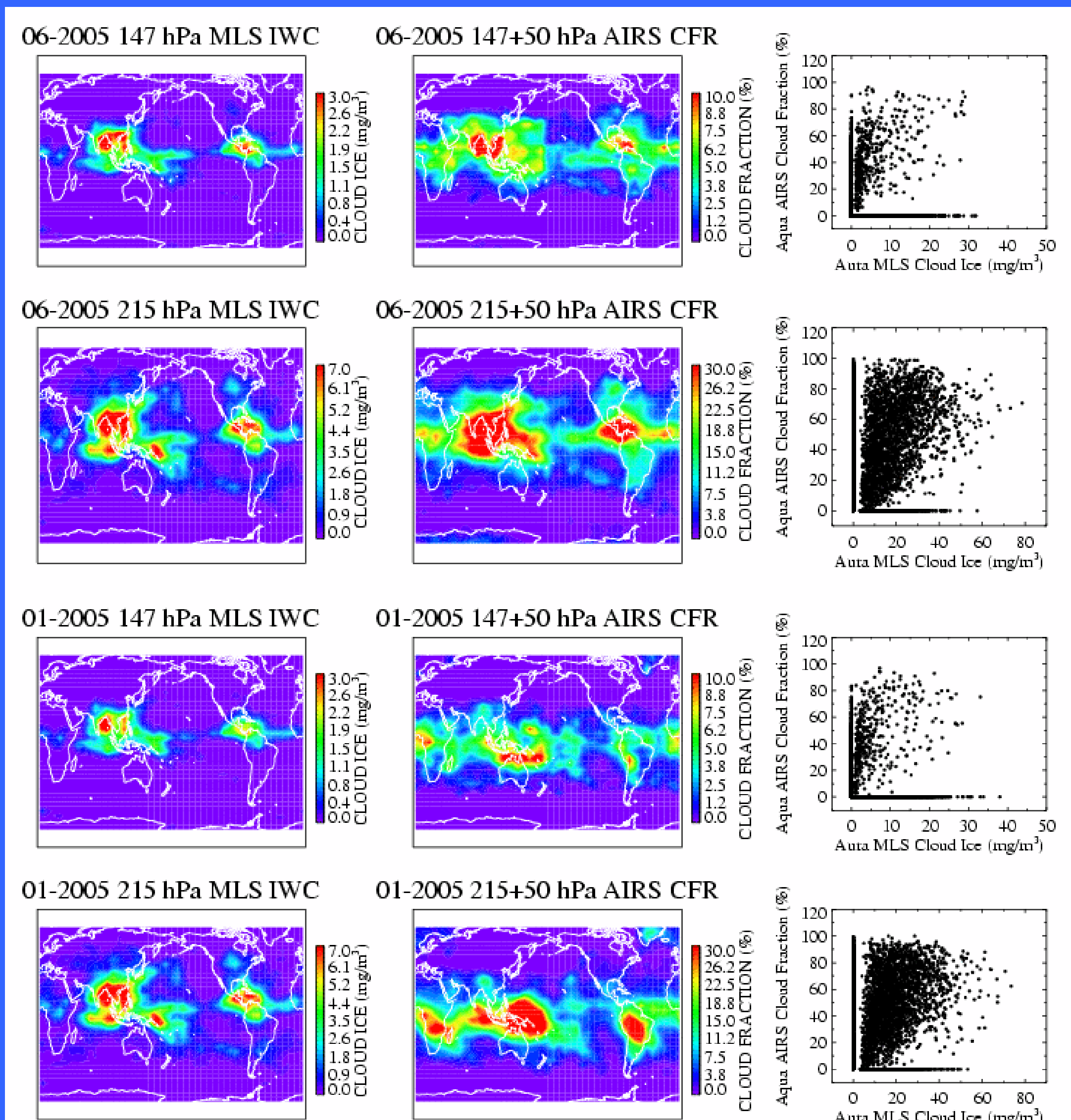


Results: AIRS seems to observe more clouds than MLS. In most places, clouds observed by MLS are also reported in the collocated and coincident AIRS ⟨**CFR**⟩ data.

There are few places MLS reported IWC but missed by AIRS. In this case, we often find AIRS did report clouds at this location but at further lower altitude (or higher CTP). Conversely, there are cases that AIRS detected clouds but MLS didn't, we note that infrared instrument like AIRS are more sensitive to thin cirrus.

Top panel: MLS IWCs measured on 27 January 2005. Lower panel: AIRS CFR sampled on the MLS track and binned for cloud top pressure ≤ 215.

Results

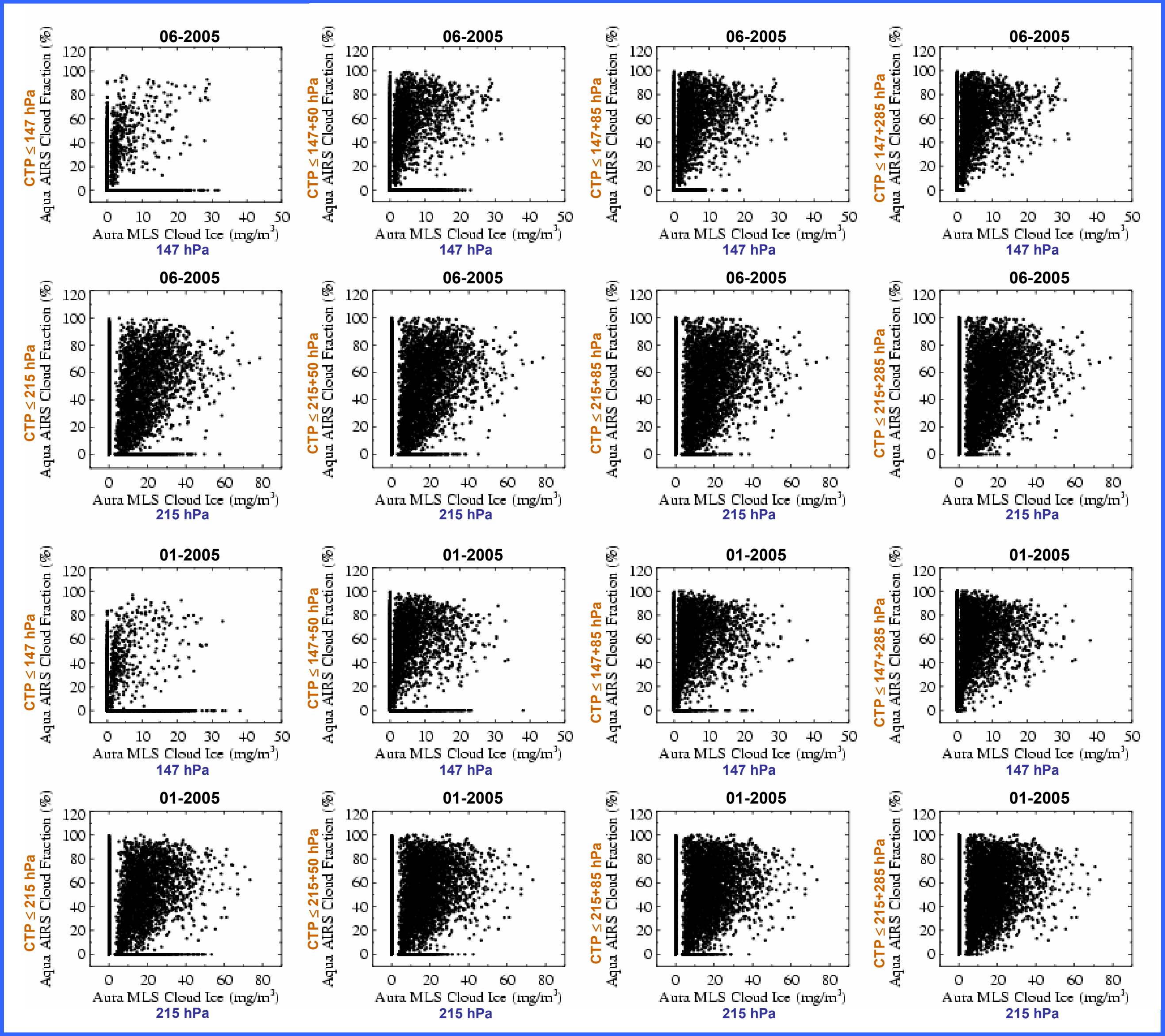


Overall morphology of MLS and AIRS observations show good agreement.

Some disagreements exist, but where MLS observes clouds and AIRS doesn't, we often find AIRS did report clouds at this location but at lower altitude (see next slide)

Monthly mean maps of MLS IWC (left-column) and AIRS ⟨CFR⟩ (mid-column) for January 2005 (lower two rows) and June 2005 (upper two rows) at 147 and 215 hPa levels. The scatter plots at right column show MLS IWC versus AIRS ⟨CFR⟩ for each single daily collocated & coincident measurement from MLS and AIRS.

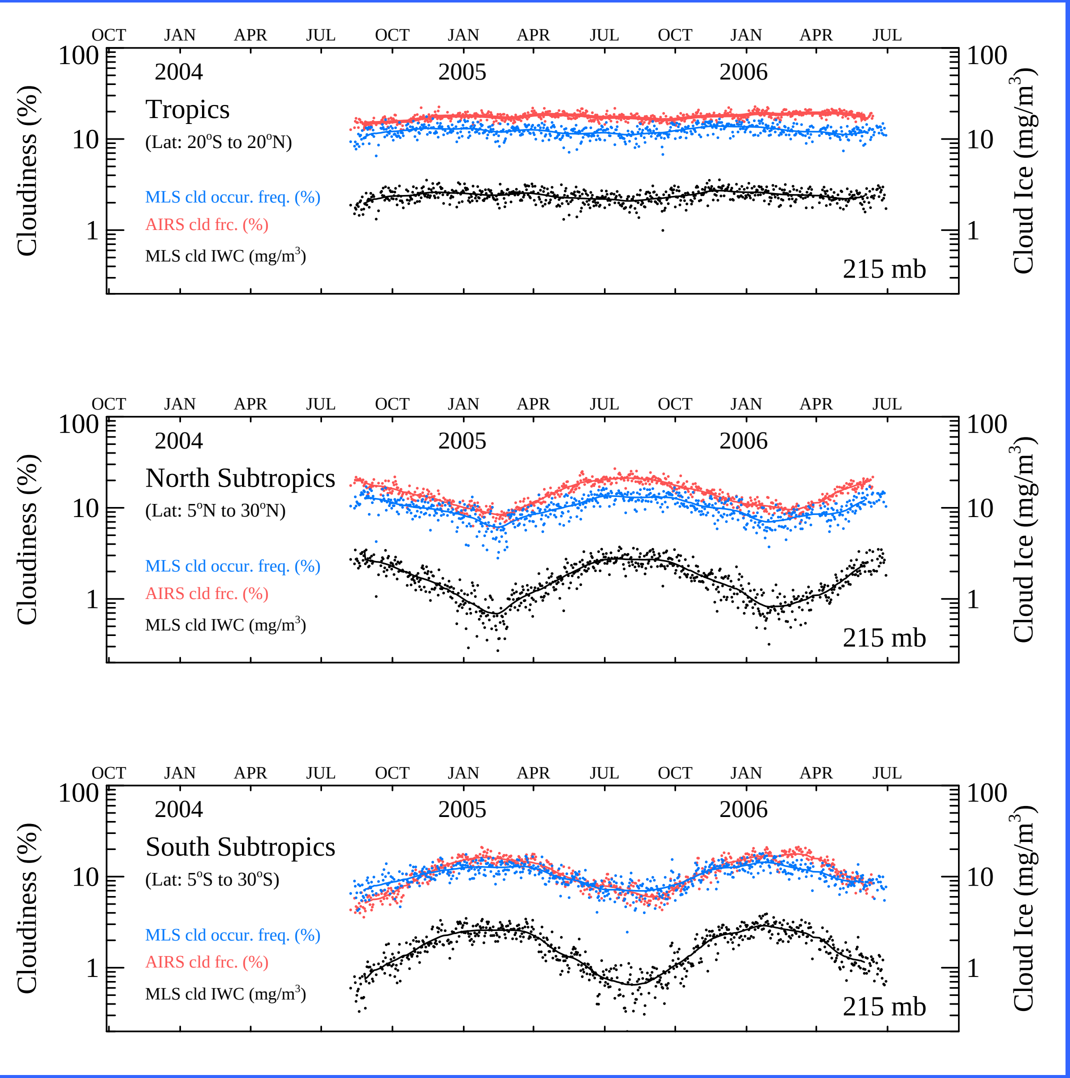
Results continue…



Figures at left show that when the AIRS ⟨CFR⟩ are binned with higher ⟨CTP⟩ (lower cloud top height), the cases of MLS cloud observations missed by AIRS are significantly reduced.

Finding AIRS clouds at same location but lower altitude

Results continue…

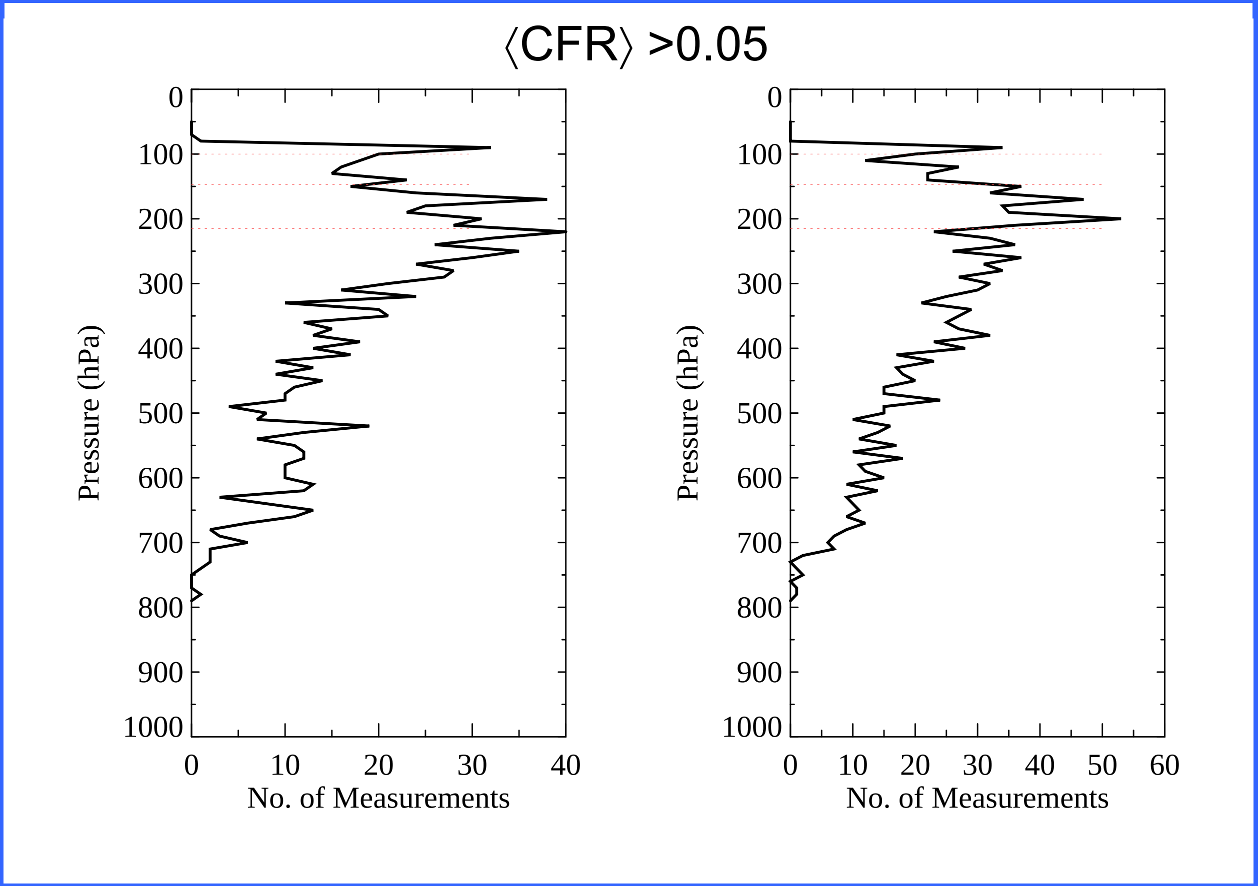


The MLS IWC (mg/m3) and AIRS ⟨CFR⟩ (%) are two different quantities and thus they can not compare directly. But time series show they have the same seasonal variation, which they should.

The MLS cloud occurrence frequency (%) is computed as total number of cloud detected divided by total number of samples. They show good agreement with AIRS ⟨CFR⟩.

Time-series of collocate and coincident cloud observations between MLS and AIRS. Each dot represents daily averages for regions of Tropics (top-panel), north sub-tropics (mid-panel) or south sub-tropics (lower-panel). The solid lines are the monthly running means of the daily values. For all three regions, the different colors illustrate the following: black is the mean MLS IWC (mg/m3), **red is the mean AIRS ⟨CFR⟩** (%), **blue is the cloud occurrence frequency observed by the MLS.**

Results continue…



Define the MLS cloud top pressure as the highest altitude (lowest pressure level) with IWC > 0 mg/m^3. Then we find all the coincident AIRS ⟨CTP⟩ for all the MLS samples at (a) 147 or (b) 215 hPa. In both cases, a large number of clouds were reported by the AIRS at lower altitudes compared to those reported by the MLS.

Frequency distribution of the AIRS ⟨CTP⟩ collocated to the MLS measurements with MLS cloud top pressure at (a) 147 hPa and (b) 215 hPa, respectively. All coincident cloud observations of January 1995 between AIRS and MLS in ±40° latitudes are used in this analysis. The vertical pressure bin for computing the number of measurements is 10 hPa. The red dotted-lines illustrate the standard MLS pressure levels.

Summary

- In summary, after interpolating AIRS data onto MLS data points, the collocated and coincident MLS and AIRS cloud measurements show good agreement of global distribution (morphology) of upper tropospheric clouds.

- The cases where MLS and AIRS show disagreement can be generally understood as caused by the difference in sensitivity and retrieval limits/caveats of the two instruments.

- The AIRS often reports clouds at lower altitudes than the MLS estimates, which are likely due to AIRS poor cloud retrieval at high altitudes in the upper troposphere.